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A PAPER

ON THE

AGRICULTURAL VALUE

OF

SEWER

AND OTHER

DRAINAGE WATERS:

SUBMITTED TO THE

METROPOLITAN COMMISSIONERS OF SEWERS,

BY

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ONE OF THE COMMISSIONERS.

[*Ordered to be printed January,* 1849.]

Printed by Reynell and Weight, 16 Little Pulteney street.

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Metropolitan Sewers.

AGRICULTURAL DRAINAGE.

I.—HOUSE DRAINAGE.

In the last session of Parliament (1847-8) two important acts were passed, whose beneficial influence upon all classes of the community will be long and extensively felt. I allude to cap. 63, entitled "an Act for Promoting the Public Health," and cap. 112, "an Act to Consolidate, &c., the Metropolitan Commissioners of Sewers." These have been already the means of great and invaluable prefatory inquiries and preliminary improvements in the drainage of towns, still, greater things will be speedily accomplished, greater power will be hereafter given to the Commissioners with advantage to the community at large, prejudices will die away, the general health (the poor man's only source of capital) advanced. I propose on this occasion, amid all these invaluable contemplated improvements of house drainage, to put in a plea on behalf of the agriculture of our country, for the extended and improved collection and use of the contents of town sewers; a sewage, as at present mismanaged, so generally useless to vegetation, and so pernicious to animal life. To this end I would, in the first place, earnestly and anxiously endeavour to impress upon my readers the public and private duty they have to perform, in aiding in every way in their power the extension of a system of complete sewage, which will not only tend to the health and longevity of their own family circle, but of all their surrounding neighbours. On this branch of the inquiry, a draft report of their surveyors to the Metropolitan Commissioners of Sewers (not yet adopted by the Commissioners) contains the following passages. They very correctly remark (p. 3), when alluding to the necessity for a general and compulsory system of house drainage, "Though absolute control over house drainage is imperatively necessary, all that is desired is the protection of the public, and this can only be accomplished by making house drainage compulsory under supervision, or in other words, by the court having power, where no house drainage exists, or where it is defective, to see to its construction or amendment: so that no man may either make his house a fever-nest and common nuisance, by refusing to construct drainage, or

make the public sewers the means of spreading miasma by connecting with them bad and inefficient works. Thus would that portion of the public who would voluntarily make the provision be secured from the evil consequences that would ensue to them from the neglect of others." The objection sometimes urged to the Commissioners of Sewers, giving the power of a public interference with private property, is well answered by the surveyor; for, when speaking of the present system, they remark—"But can he—does he, do as he likes with his own? With defective or deficient drainage he is a very slave in his own house, at the mercy of a host of irresponsible workmen. It is true that he sends for them, but he cannot help himself. It is only when the overflowing cesspool or the choked-up drain is no longer bearable, that this mitigation of the evil is forced upon him, and from year to year is this unwelcome visit repeated. Nor is this all; yet more unwelcome visitors, sickness and disease, force their way in by the same channels in spite of him, and those are happy who escape the most unwelcome visitor of all—death, too often prematurely summoned to these scenes of neglect and apathy." This, however, is a middle and upper class view of the subject. The poor man suffers so immediately —intensely and needlessly suffers—from this neglected and anomalous state of things, that he would hail with heartfelt satisfaction the most intrusive interference that would improve the cruel circumstances under which he is thus compelled to exist; but scarcely yet aware of the intimate connection of his misery with the neglected conditions around him, his voice is not so audible in favour of the change. So great and so constant, indeed, are the evils arising from defective house drainage, that it is a matter of thankfulness that our senses become deadened, and, as it were, acclimatised to the wretched atmosphere with which we are surrounded; for although this state of things engenders a low and depressed condition of existence, and produces a high rate of mortality, it would be still more fatal if we had no tendency to become accustomed to it." I regard, then, the systematic and perfect drainage of houses as no longer capable of being regarded as a doubtful question. Preliminary measures are now taking, in all parts of the country, for carrying out the provisions of the valuable acts of parliament to which I have alluded: something good has been already done, and still greater operations than any yet contemplated will be soon accomplished. Amid these great efforts, let me urge upon the attention of the constituted authorities the importance of adopting, on all practicable occasions, that arrangement of the drainage of houses which shall afford the greatest facilities for the employment of the sewage for the purposes of irrigation. It is often practicable to so construct the drains of populous places, that, with a proper attention to the requisite fall, the outlet of these sewers may be so far elevated as to allow of the liquid matter which they discharge being passed over cultivated lands on its way to the adjoining river. Such opportunities as these should on no account be neglected. By the use in this way of the sewage, the land is enriched, the river water less injured in its purity; since, after being employed in water meads, the sewage often flows off the land in a state very nearly colourless. It is not easy to

value exactly the matter annually discharged through a town sewer, but still a considerable and very valuable approximation may be made. The most practical way of illustrating my position would be by referring my readers to the cases of the lands so copiously, so extensively, and very profitably irrigated by the contents of the public sewers of Edinburgh, and at Clipstone, close by the town of Mansfield. But another and rather more definite course may be adopted, that which one or two great chemists have followed, to obtain an approximation to a correct estimate. "A thousand pounds of urine," observes Professor Johnston (*Elem. Agricultural Chem. p.* 158), "contains 68lbs. of dry fertilising matter of the richest quality, worth, at the present rate of selling manures in this country, at least 10s. per cwt. As each full grown man voids about 1,000lbs. of urine in a year, the national waste incurred in this form amounts, at the above valuation, to 6s. per head. And if five tons of farm-yard manure per acre, added year by year, will keep a farm in good heart, four cwt. of the solid matter of urine would probably have an equal effect; or the urine alone, discharged into the rivers by a population of 10,000 persons, would supply manure to a farm of 1,500 acres, yielding a return of 4,500 quarters of corn, or an equivalent produce of three crops." Of another valuable portion of the heterogeneous contents of a sewer, M. Sprengel, when speaking of nightsoil, remarks (*Journ. R.A.S. vol.* 1, *p.* 494), "Although there can be no doubt that this material is one of the strongest manures, it is still in most places managed with less care than any, and in many altogether neglected; yet the greater or less value attached to it in any country is certainly a proof of the degree in which the agriculture of that country is advanced. Where pains are taken with it, husbandry will be found in other respects excellent; where it is little thought of, the art, in general, will usually be less perfect." It is to the use of this substance, drawn from reservoirs in the towns, that Belgium in a great degree owes her fertility; while in many large cities of Germany it is allowed to drain into the rivers. Since 1,200lbs. weight of it yearly may be reckoned for each unit of population, it is easy to see, where population is counted by thousands, how important its application must be. The value of the sewage of houses is certainly more generally understood on the Continent than with us. In most of the German towns (*Johnson on the Fertilizers, p.* 107), the householder disposes of the contents of his cesspool for a certain sum of money, besides getting the operation performed gratuitously. By comparing the returns of the different prices paid in those cities for the commodity in question, one year with another, and equalising them by an average price, the inhabitants appear to be benefited to the amount of four francs a head yearly, and the middleman to at least 40 per cent. on the sum he pays to the householder. It is true that these matters in a common sewer are mixed and diluted with a very considerable portion of water; but this is no bar to its use in irrigation (I make the remark more for the use of the general reader than the farmer), since, in the case of water meads, the town sewage is found to be abundantly powerful; so much so, indeed, that in the case of the meadows watered by the sewage of Edinburgh, its strength is sometimes

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deemed too great; and yet, observes Mr Stevens, in his valuable "Practical Irrigator," when speaking of these sewer-watered meads, "the grass is let every year by public sale in small patches of a quarter of an acre and upwards, and generally brings yearly from 25*l.* to 30*l.* per acre." I feel that in these rapid preliminary inquiries I have only employed a few of the many facts in my possession, all tending to prove the same thing. I shall in the following pages gather together more evidence on this national improvement, but in this little section I will only say to the friends of sanitary reform, in all your noble efforts to add health and comfort to the community, to which I bid God speed, do not forget the claims, the demands, and the benefit of agriculture.

II.—THE VALUE OF SEWAGE WATERS IN IRRIGATION.

An objection is sometimes raised to the use of the sewage of towns for irrigation. that although the substances it contains are very fertilising, yet the proportion in which it is found is too small for its useful employment. The objection then is, that the liquid is very commonly too much diluted with water. Such objectors are not commonly aware of either the pretty uniform strength of the contents of town sewers, the largeness of the mass of rich organic matters which they convey away, or the value of liquid manure to the farmer's crops, in even a far more diluted state than that in which it is found in ordinary periods in the sewer of an English town. In directing, then, our attention to these objects on the present occasion, I feel that we are likely to be labouring in a very useful direction. It is, in fact, in vain to expect the landholder to make any efforts to avail himself of these enriching waters, if he is in doubt as to their fertilising power. The composition of the sewage waters of both large and small towns, in periods of dry weather, seems to be much more uniform than might be reasonably anticipated. This will be readily seen by comparing the composition of the sewage of the small town of Mansfield, in Nottinghamshire, with that of the cities of Edinburgh and Westminster. The composition of the Mansfield sewage was some time since ascertained by Mr T. J. Cooper. One gallon of the *clear* liquid, evaporated to dryness, gave 77.3 grains of solid matter, containing—

	GRAINS.
Ammonia	4.02
Chlorine	9.63
Lime	7.10
Sulphuric acid	2.63
Magnesia	1.05

There was also found with potash, soda, and animal and vegetable matter, in a soluble form, phosphate of lime, 0.9; earthy matter and sand 1.6 (*Report of Com.*

on Metro. Sewage, p. 153). The sewage water of Edinburgh, also examined by Mr Cooper, was found to contain per gallon 78 grains of solid matters: these were also composed of a quantity of soluble animal and vegetable matters, some potash and soda, and

	GRAINS.
Ammonia	4.45
Sulphuric acid	3.00
Lime	6.84
Chlorine	12.10
Phosphate of lime	1.06

The composition of the London sewage is very similar to those of the above-named towns. A gallon of the liquid portion of the sewage water of the King's Scholar Sewer was found to contain 85.3 grains of solid matter. This consisted of a large proportion of *soluble* animal and vegetable matters; besides the following substances (*Appendix to Report, p.* 153) :—

	GRAINS.
Ammonia	3.29
Sulphuric acid	0.62
Phosphate of lime	0.29
Lime	6.05
Chlorine	10.00

With some potassa and soda.

The mechanically suspended matters of a gallon of this sewer water amounted to 55 grains; of which 21.22 grains were combustible, and consisted of animal matter rich in nitrogen, some vegetable matter, and a quantity of fat, and 33.75 of matter consisting of—

	GRAINS.
Phosphate of lime	6.81
Oxide of iron	2.01
Carbonate of lime	1.75
Sulphate of lime	1.53
Earthy matter and sand	21.65

Such, then, is the ordinary composition of town sewer water. The largeness of the stream which these drains contain is as little generally understood. On the contents of one of these we have the advantage of possessing the evidence of Mr James Smith, of Deanston (*Minutes of Evidence, Metro. Sewage, p.* 1), who, when alluding to the King's Scholar Pond Sewer, of Westminster, told the committee that the quantity of sewage which this drain discharges into the Thames annually is very nearly six millions of tons. In reply to a question as to the ordinary composition of this mass, he added, " It is very difficult to ascertain correctly the different compositions of sewer water, because it varies very much; but we have endeavoured to have water taken so frequently at stated periods as to give us what we think a fair average, not in wet weather, but in weather when the sewers are likely to have a greater proportion, or at least an average proportion of sewage water in the sewer, and from the

investigation of our chemist, we find that there are about 92 grains of solid in suspension and solution per gallon; that is equal to 400lb. weight in a hundred tons. The greater part of the matter that is in suspension is either light matter floating upon the surface, or very much divided, pretty nearly of the same specific gravity as the water, and consequently floating all through it. There is a proportion of the heavy matter of silt, and the debris of the stones of the street, and of the sand that gets in in various ways, &c.; but that forms but a very small proportion." "A proper view of the thing as it exists may disabuse the minds of many (very correctly added Mr Smith) of their notions of sewer water. I have found, from conversing with persons who have not considered the subject, that they conceive it to be a thick unctuous matter, difficult to deal with, and difficult to pump above all things; on the contrary, it is nearly as fluid as the water pumped in for the supply of towns." Towards the close of his evidence, Mr Smith made the very just remark (and it is one highly encouraging to those who are labouring to improve the system of house drainage, and to apply town sewage to the purposes of agriculture) "that as to the condition of sewage water, there is no town that has one-half the condition in the sewage water that it ought to have, if that town were properly drained. At present, even in some of the best districts of London, a great deal of the valuable animal matter is entirely thrown away: there are no urinals, and not a sufficient supply of water-closets; most of them connected with even the best houses are discharged into the cesspools; the matter soaks into the ground, and causes great nuisance to the inhabitants, and is entirely lost; but a proper system of pipe sewage from the water-closet directly, and from the different slop places in the house, if it were carried out in proper air-tight pipes, and connected with the proper sewerage, I am quite sure the sewage water in drains would be then worth double the money it is at present. From the experiment which I made upon the urine of two persons kept for a year, and mixed with ashes, it would be sufficient to raise a fair acre of turnips. I am quite sure (he concluded), with regard to the subject of liquid manure generally, that the same quantity of enriching matter applied in a liquid form will be very much more efficacious and more quickly so than in a solid state." This leads me to the third portion of my observations—the fertilising value of liquid manure, even when so extensively diluted with water as in a town sewer. On this branch of the inquiry, before I quit the evidence of Mr Smith, I may add his remark on this head when he said (236), "I may mention a very interesting experiment by Mr Knight, the nurseryman, who has for the last four or five years converted a well, which he had in his nursery to supply water to his plants, into a tank. He has a privy connected with it, and he employs from 28 to 30 persons, all of whom use the privy, and all this matter goes into the well. He pumps it up with a mixture of water from the well, and applies it to his plants, and has had the most extraordinary results produced. He has been rewarded with the most vigorous growth of plants in this country, and has been enabled to bring some exotic plants to a luxuriance of growth equal to what they reach in their own climates." The remarks of

Sir H. Davy and of Liebig (*Organic Chemistry*, p. 195) tend to the same conclusion as to the advantage of dilution. The great German chemist observes—" In respect to the quantity of nitrogen contained in excrements, 100 parts of the urine of a healthy man are equal to 1,300 parts of the fresh dung of a horse, and to 600 parts of those of the cow." Hence it is evident that it would be cf much importance to agriculture if none of the human urine were lost. His remarks upon the amount of this bear directly upon my argument, although not exactly upon this portion of it, when he adds—" If we admit that the liquid and solid excrements of man amount on an average to 1½ lb. daily (1¼ lb. of urine, and ¼ lb. of fæces), and that both taken together contain three per cent. of nitrogen, then in one year they will amount to 547 lb. which contain 16.41 lb. of nitrogen—a quantity sufficient to yield the nitrogen of 800 lb. of wheat, rye, oats, or of 900 lb. of barley. Davy long since found the necessity for using liquid manures in a diluted state. " I found," he remarked, when lecturing before the members of the Royal Institution (*Lectures*, p. 270), " by some experiments made in 1814, that plants introduced into strong fresh solutions of sugar, mucilage, tanning principle, jelly, and other substances, died; but that plants lived in the same substances after they had fermented. At that time I supposed that fermentation was necessary to prepare the food of plants, but I have since found that the deleterious effect of the recent vegetable solution was owing to their being too concentrated; in consequence of which the vegetable organs were probably clogged with solid matter, and the transpiration by the leaves prevented. In the beginning of June in the next year I used solutions of the same substances, but so much diluted that there was only about one 200th part of solid vegetable or animal matter in the solutions. Plants of mint grew luxuriantly in all these solutions, but least so in the astringent matter. I watered some spots of grass in a garden with the different solutions separately, and a spot with common water; the grass watered with solutions of jelly, sugar, and mucilage grew most vigorously, and that watered with a solution of the tanning principle grew better than that watered with common water." It is well worthy of notice in such an inquiry, how speedily the addition of the contents of a town sewer, even to a copious rapid stream, imparts to it increased fertilising power for the irrigator. There is hardly to be found, considering the short extent of its course, a more copious, a brighter, or a more rapid stream, than the Itchen. Whoever has noted the large volume of water rushing under the bridge at Winchester, would be little inclined to suspect that the addition to it of the matters from one or two sewers of that very wretchedly drained city would perceptibly increase its value for the farmer; and yet the owners of the water meads of the Itchen valley are " perfectly aware of the value of the addition of the city drainage of Winchester to the fertilising qualities of the river water, and of its superiority for irrigation after it has flowed past the city." (*Johnson's Fertilisers*, p. 239.) The landholders near Salisbury give the same evidence in the case of the sewage of that city poured into the waters of the Wiltshire Avon; and when Mr J. E. Denison

was describing the formation of the great and valuable water meadows at Clipstone, made by his Grace the Duke of Portland, and watered by the little river Maun, he observed (*Journ. R. A. S.*, vol. i, p. 362), "The *quality* of the water is very important: soft water is the best; mineral waters, and waters from peat-mosses and bogs, are found to be injurious. After strong rains the washings of the streets and sewers of the town of Mansfield, which discharge themselves into the Maun, give great additional efficacy to the water. Mr Tebbutt, the manager of the works, compares its virtues in that state to ale, when in its ordinary condition, it would not deserve a better name than that of small beer. It will sometimes deposit a sediment in one watering of the thickness of a sheet of paper." The evidence of the Italian farmers in the neighbourhood of Milan, so much celebrated for their valuable water meads, is to the same effect—a detailed account of these will be found in the first *Report of the Health of Towns' Commission*, p. 403. In describing the course of one of the great canals which carries off the sewage of the city of Milan, it is there remarked, "The Vetabbia flows out of the southern part of the city, and after a course of ten miles discharges itself in the river Lambro, fertilising prodigiously a considerable extent of meadow land." It can be easily conceived what must be the fertilising quality of the Vetabbia, as it carries off all the filth of a city of 150,000 inhabitants, and the quantity of fertilising matter borne along by its waters raises in such a manner the surface of the meadows it irrigates as to render it necessary that from time to time the deposit should be removed in order to preserve the level of irrigation. The deposit is by itself an excellent manure, and is bought by the neighbouring agriculturists as a fertiliser. The Vetabbia possesses also the valuable peculiarity of protecting from frost the meadows it irrigates, owing to the high temperature it receives in its passage under the town. Some of the meadows irrigated by the sewerage water of Milan yield a net rental of 21*l.* per *tornatura* (a measure of 10,000 square metres, equal to about 2½ acres), besides a land tax of 61 francs 10 cents., the expenses of administration, repairs of buildings, &c. These meadows are mowed in November, January, March, and April, for stable-feeding: in June, July, and August they yield three crops of hay for the winter, and in September they furnish an abundant pasture for the cattle till the beginning of the winter irrigation. The evidence, then, of both the chemical philosopher and the skilful practical irrigator all tends to establish clearly the same facts—that the addition of a portion of the saline and organic matters of town sewers, to the waters usually employed in the irrigation of grass lands, *very materially* adds to their fertilising powers. It is a result which can hardly be too generally known by the farmer and by the philanthropist. It will aid the first in his great efforts to increase the supply of food to an increasingly crowded population—it will assist the last in his noble endeavour to diffuse health and comfort amongst the poor, and at present neglected, districts of all large towns. It will arm both with another argument to arouse those most directly interested in the course of sanitary improvement; since it

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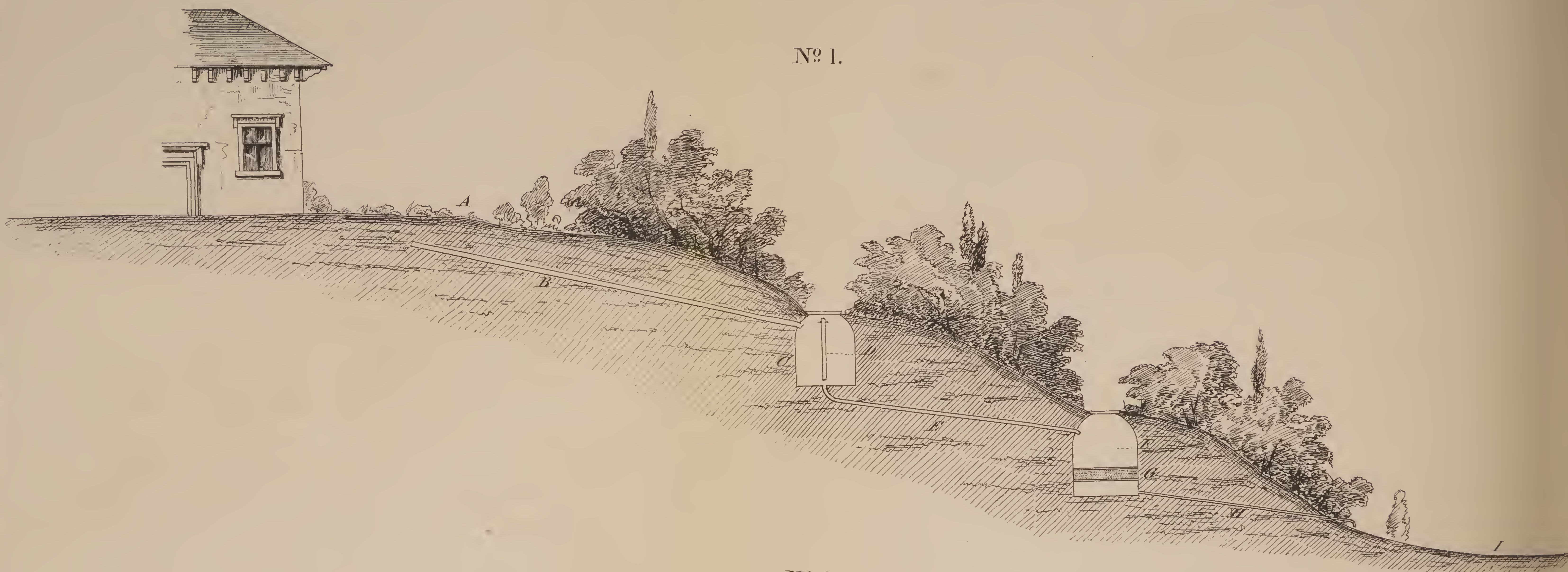

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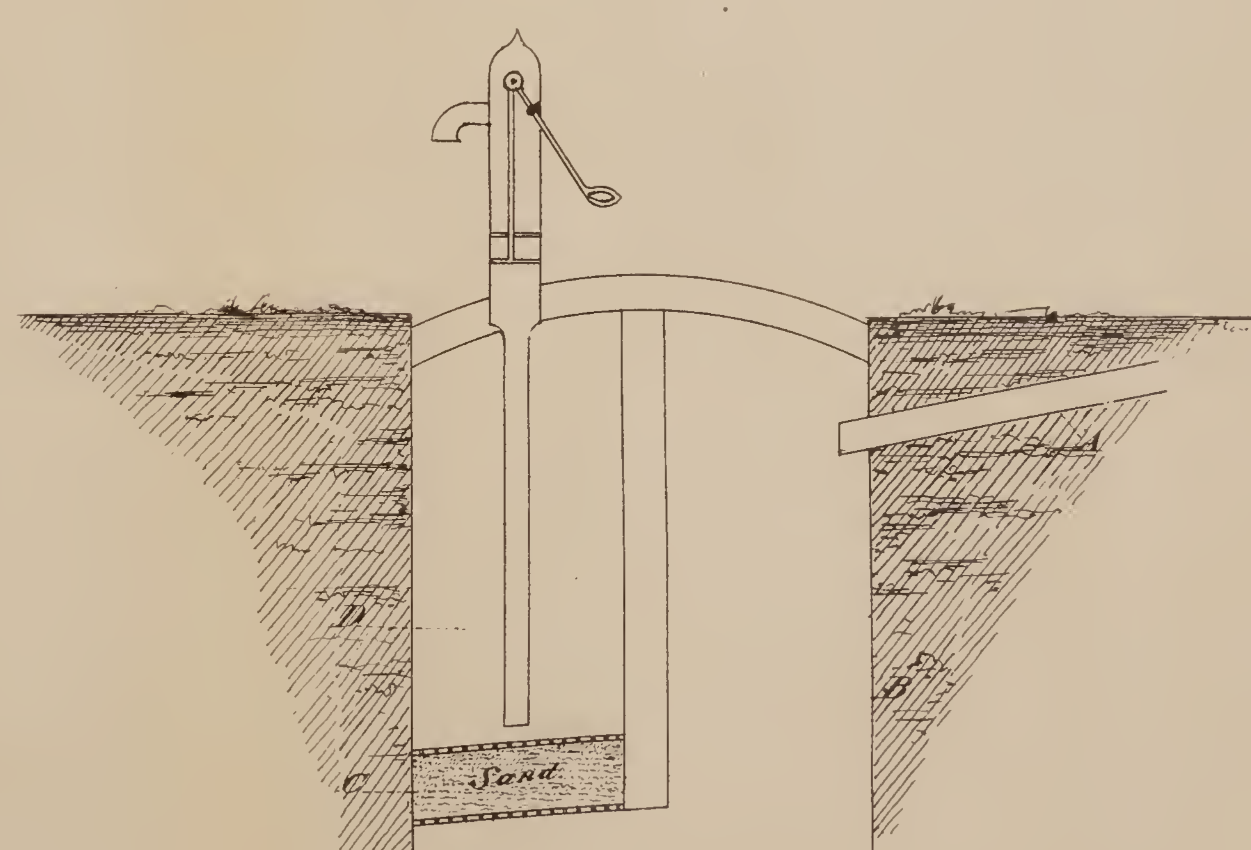

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is evident that what is at present, when putrefying in tanks, either breeding noxious gases, or contaminating the waters of the adjoining wells, will, when by a perfect system of sewerage rendered available for the purposes of irrigation, be the means of affording food for the very animal life to which it is at present the cause of disease and misery.

III.—THE EMPLOYMENT OF HOUSE-SEWAGE IN GARDENS.

If we are convinced by evidence as powerful and as satisfactory as that which I have adduced of the value of the sewage of the house for the use of the garden and the field, it next becomes an interesting inquiry to endeavour to find a means by which this at present worse than wasted source of fertility may readily, and without the slightest annoyance to any of the inmates of the house, or the visitors to our gardens, be usefully and very profitably employed. In this there is little practical difficulty; for, as I have experimentally ascertained, the entire sewage of a house (using the word sewage in its most comprehensive sense) is readily filtered through coarse sand; and in my own case, after having for several months adopted this plan, the filter still allows the fluid portion of the sewage to pass through with little diminution of its rapidity. The fluid portion, after being filtered, merely presents the appearance of dirty ditch water; it has a slightly disagreeable smell, but this ceases as soon as it is added to the ground; the whole of it rapidly soaks in, without leaving either any mechanically suspended matters, or even a stain on the surface of the mould.

In my own case, at my residence at Waldronfield, in the parish of Croydon, feeling the danger of leakage in the ordinary brick drains, I employed only leaden or cast-iron pipes (five-inch bore) for the entire length of the sewers; and as between my house and its kitchen-garden there is fortunately a sufficient fall to admit of the construction of a separate receiving tank, and also a second tank (both made of bricks, set in, and faced with cement) furnished with a sand filter, I have no occasion to use a pump to raise the filtered sewer water. The fall in my case is sufficient to enable the filtered liquid manure to flow through small ¾-inch iron pipes to every portion of the kitchen-garden, as represented in the annexed plan; in which A A A represents the surface of the ground; B, the sewer through which the sewage of the house is conveyed to the receiving tank C, from which, by lifting the plug D, the sewage, as occasion requires, is let through the pipe E into the tank F, where it filters through the filter G, and is then conducted by means of the pipe H into the kitchen-garden I. In every communication from the house to the drain B, a self-acting water-valve effectually prevents the escape of any effluvia. Both of the tanks are furnished with man-holes and stone covers. These tanks hold about five hundred gallons each, and from an establishment of five persons the tank

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c is filled by the sewage in about a week. The facility thus afforded for carrying away house-sewage, and its profitable employment on the land by placing a dwelling-house on the side of a sloping ground, afford two most powerful additional arguments for choosing such sites for the erection of our dwellings. In those situations where it is necessary to employ a pump, the great objects of employing the sewage and filtration may be readily obtained by even a single tank, by merely dividing the tank into two compartments, and then allowing the sewage to filter through a filter of coarse sand, supported on a false bottom. In my case I have adopted for the false bottom the tiles with which the floors of the maltsters' drying kilns are laid. These are perforated with small holes; on these is laid a stratum of coarse gravel about two inches thick, and then about three inches of coarse sand. In my filter, as the sewage, when the plug of the upper tank is raised, rushes in the lower tank with some force, I have laid upon the top of the sand another paving (laid in both cases without any mortar or cement) of these maltsters' tiles. By this means, the sand is not disturbed when the sewage pours in, and the operation of cleansing the filter is facilitated. This operation of cleansing, however, will apparently be only an annual and quickly-performed operation. The second plan to which I have referred, by a single tank (which should of course be made water-tight), may be more readily understood by the following outline.

In this, the sewage is conveyed from the house by the pipe A into the division of the tank B, and rises through the sand filter C into the division D, from whence it is raised by a common iron lifting-pump. The tank may be made of brick or any other suitable material, should be made water-tight by cement, and its cover be provided with a man-hole, for the purpose of occasional cleansing. The effect of the filtered sewage upon vegetation is fully equal, I find by experience, to anything I have before witnessed. In the case of the garden at Waldronfield, we have had to contend with the effects of a newly-formed garden. (The kitchen-garden was only first laid out in March 1848.) Our asparagus, rhubarb, and sea-kale beds, only made in the spring of 1848, have been all copiously irrigated with this liquid, and their growth has been such as to attract the notice of every one who has visited the garden, every stranger to the place feeling convinced that the growth of all these could hardly be more luxuriant had they been much longer planted. The effect upon cabbages, and others of the Brassica tribe, is most powerful; my gardener waters with it all the newly-set plants, and their rapidity of growth is fully equal to what might have been expected from such grossly-feeding plants. We have not found any kind of plant to which it may not be advantageously applied, either flowers, evergreen, fruit or timber trees. To young plants of all these we have applied it, and in every case with the most marked advantage.

IV.—THE STRONG LIQUID MANURE OF SEWERS.

There are one or two recent efforts for the promotion of the public health, which, in their results, promise well for practical farming, for they tend to collect and render available, in certain localities, an abundance of liquid manure. I allude more particularly to the increase of available sewage matters, by the certain results of the proposed sanatory regulations, and the collection of the sewage matter for the use of the farmer by the different Sewage Manure Companies. It is true that the mode in which some of these propose to carry out their invaluable objects may be open to objection, that in all probability they will have to adopt much more extended plans than the pumping of the sewage water over the farmer's land through leathern hose, and that they will have to irrigate land much more distant from the town, and much better suited for irrigation, than that which some of these companies have chosen for their primary attempts. This may *retard*, it is true, the acquisition of the full advantage which is certain to arise sooner or later to agriculture, and to the general health and comfort, by the diversion of the sewage matters of populous places from their present pernicious direction; but these errors will be easily avoided in future. The system which has been carried on in the neighbourhood of Manchester, by the Sewage Manure Company of that town, affords an instance of the good management, not exactly of the contents of the sewers, but of the richer liquid portion of night-soil, which I think may be readily imitated by many of my friends who are farming on the banks of canals and rivers which communicate with large towns. This plan has been recently described in a communication made by Dr Guy and Mr Sherborne to the Metropolitan Sewage Manure Company, in which they remark (*Agricultural Gazette*, 1848, p. 42)—"The manure employed by the Manchester Liquid Manure Irrigation Company, is the more liquid part of night-soil unmixed with other refuse matter, and as concentrated as it can be procured. It is brought to the store tanks on the banks of the canal in large water-carts, mounted on wheels, at an average cost of 3s. per ton. The price varies with the quality, which is determined by its specific gravity. The higher the specific gravity of the liquid, the higher the price given for it. It is absolutely necessary to apply some test, as attempts have been made to adulterate even this article of commerce. The manure is stored in uncovered tanks, and is therefore liable to be diluted with the rain which falls on its surface, or drains into it. With a view to fix the ammonia, gypsum is added in the proportion of about ½ cwt. to from twenty to forty tons. The contents of the tank are transferred to the barges by means of a syphon. The quantity of this liquid applied to an acre of

ground is three tons, diluted, according to the state of the soil, with from three to six times its bulk of water. The contents of the tank are by no means so offensive as might be expected, though covered with a scum, and emitting bubbles of gas; and the same remark applies to the liquid when transferred to the barge and shaken by the motion of the vessel. When diluted with three times its bulk of water, as on the day when we witnessed the operation, the odour is very perceptible, but neither very offensive nor very enduring, and certainly much less offensive than that of many manures in common use. We are informed that it disappears in about three hours, and that cattle will eat the grass on the following day, or even on the same day. When diluted with six times its bulk of water, the smell is but very slightly perceptible half an hour after its application, *and in no case is any annoyance occasioned to the neighbourhood.*" The charge for a single application of twenty tons to the acre is, it seems, 1*l.*, and 6d. additional is charged for each mile the manure and necessary apparatus have to be carried from Manchester. The demand for the liquid manure, it is added, is on the increase, although it has evidently been often applied to grass land, ill adapted, from want of drainage and other preparations, to display its powers to the greatest advantage. It is indeed only by slow degrees that these improvements are adopted. This very plan was long since described by a Swedish farmer, the Baron de Schulze (*Com. Board of Agri.*, vol. i, p. 326), who, when writing to Sir John Sinclair, observed:—"They have now ceased to spoil the fine harbour of Stockholm with nuisances of every kind. The contents of the privies are now collected by undertakers, in barrels of which they are obliged to have a double quantity to replace those deposited in the reservoirs, from whence they are carried to the country. My eldest son, who has changed the sword for the ploughshare, has particularly attended to this manure, being favourably situated on the Lake Malar, forty-eight English miles from the capital; he conveys it in a covered boat, each loading of which is sufficient to dress about three acres of spring corn, and between four and five of winter corn and meadow ground. This manure, by the motion of the boat, becomes more liquid, and is conveyed from the hold of the vessel by a bucket at the end of a lever, through a spout into a close cart on shore, drawn by two oxen. These carts are provided with a moveable funnel, and with a strainer so regulated by means of a pole, that the manure can be administered at pleasure by the driver, without further attention to spreading. That the land may not be overdunged, and the crop consequently lodged, care must be taken not to lay above forty such cart-loads on the Swedish acre for spring corn; each cart containing 180 gallons English, or 1,920 lb. (The Swedish acre contains 46,770 4-5 square French feet; the English acre, 38,285 ditto.) Except that other powerful manure produced by the herring oil works refuse, none can come into competition, for richness, with the contents of the privy mixed with urine: the effects of this manure, no doubt, diminish gradually, yet its operation may be plainly perceived in the fourth successive crop. When clover is meant to

be sown with the spring corn, this species of manure is unsuitable; for although the seed be diminished to one-third, the straw becomes so thick and strong as to choke the clover."

But I feel that the use of liquid manure need not be confined to those localities which border on canals or rivers. There are many situations where the land is furnished with steady supplies of water, when much may in this way be accomplished. Of this description is the case recently so well described by Mr Chadwick, in his evidence before her Majesty's Sanatory Commission (*Report*, p. 108), when he told the Committee, "A friend of mine in Scotland, Mr Barber, of Muirdroachwood, has twenty-seven acres of land before his house, and the land was so poor that it originally only fed two cows. He had forty cows and four horses in a stable close to his house. He put the dung of these cows into a tank, and passing a rill of water through the tank, he irrigated with it twenty-two acres. With the miscellaneous refuse of his house, he irrigated in the same way, I think, five acres. The produce was so large, that on the same spot he has been enabled to feed the forty cows and his four horses. It was a very important experiment as to the result of the comparison between effects of the liquid and the solid manure. There were some knolls of land, close by, which were elevated, and which he could not irrigate, and in consequence, whilst he has got four or five fold crops by the application of the liquid manure, with all the top dressings he has been enabled to use, he has never been able to get more than one and a half fold of produce from the same sort of manure in the state of dung. I have had (continued Mr Chadwick) a number of other experiments made, all to the same purport, and one thing I find from the horticulturists, that those who grow large produce, and obtain prizes, almost invariably, so far as I have heard, do it by the application of manure in the liquid form. I have obtained this further very important conclusion from such facts as I have collected, that the extent of dilution, such as extinguishes smell, is about the best state for absorption or assimilation by the plant; that all the progress is made by diluting more and more, and applying more and more frequently. A very able horticulturist, Mr Pince, near Exeter, tells me, 'I give this water with the manure in it so clear, that if you were not to know what it was, you would not object to drink it.' I had," he continues, "communication from the late Mr Oliver, one of the most able men in Scotland, who had a portion of the irrigated meadows near Edinburgh, and he stated that their great difficulty was the want of water, the means of dilution. It appeared, when I visited Edinburgh, from the testimony of better judges, because practical men, that that was about their chief difficulty, getting a command of water to dilute and apply the sewer water with the best effect." The effect, then, of the sewer matter is not produced by the great *strength of the liquid*—the owners of the Edinburgh meads do not prize it so much for its concentrated richness as for the copiousness of the supply. With one more testimony to the value of the sewer water I will conclude this section. "I had," said

Mr James Smith, of Deanston (*Report*, p. 13) "another set of experiments made at Stirling, on a sandy loamy soil. First, a division of the land was manured with farm-yard dung and ashes, mixed at the rate of twelve tons per acre, and at a cost of 48s.; a second portion with the same compost at the rate of sixteen tons per acre and a cost of 64s.; a third division with guano, 2 cwt., costing 16s.; a fourth with guano, 4 cwt., at a cost of 32s. Another ridge similar to the whole of this was manured with sewer water at the rate of sixteen tons per acre, and, taking it at 3d. per ton, the cost would be 4s. per acre. The average produce of the whole variety of the manured portions was forty-five bushels per acre of good barley; that with the sewage water averaged forty-two bushels, showing that this small quantity of sixteen tons had the effect of very nearly coming up to the dung and the guano." The benefit of improved town drainage then is, we see, twofold. The very operation, let me again repeat, which removes from the citizen the source of disease and misery, conveys riches and prosperity to the farmer.

V.—THE COMPOSITION OF SOME OF THE RIVER WATERS USED IN IRRIGATION.

There is perhaps hardly a single mode of raising grass so simple and so profitable, yet so little regarded in many districts, as by irrigation. The farmer whose land has naturally the command of a good stream of water, or who collects and stores in reservoirs an adequate supply for the use of his grass, possesses in fact an advantage, even if his mead is of very limited extent, that can hardly be too highly valued. It is an advantage, let the cultivator remember, not confined to the growth of copious summer crops of green food for soiling of the best kind, but the supply of manure for the farm from this source is large and uniform; the live stock on such farms being better fed, their manure keeps steadily adding fertility to the land. I am quite sure that much more would be accomplished in the way to which I allude, if the landowner did but reflect upon the value of such meads, and the ease with which, in so many situations, they are constructed on soils having a tolerably porous or readily-drained substratum. Let them banish from their minds the conclusion that it is only waters distinguished for their richness in organic matters, or the salts of lime, that are adapted for irrigation. It is true that the banks of the bright rivers of the great southern chalk formation are remarkable for their noble water-meadows, and that those waters which receive the sewage drainage of towns are still valuable; but the result of all recent researches evinces that, if the stream is copious in extent, then the smallness of the proportion of solid matter which its water contains is no obstacle to its use for the production of grass. Let us, then, take a

brief glance at what more than one great farmer has, within these last few seasons, been enabled to accomplish successfully in this manner; and let us, for our effort to be the most useful, examine what has recently been done in this way first with some of the sewage-enriched lowland waters, and then see what in other districts has been accomplished with those of even the purest and most upland mountain streams. The detail, for instance, of the great improvements carried on at Clipstone Park, by his Grace the Duke of Portland, is full of interest. As I have in another place remarked, these meadows, which extend over about 300 acres of the naturally poor soil of Selwood Forest, are thus described by Mr J. E. Denison (*Jour. Roy. Agric. Soc.*, vol. i, p. 359): "The eye, after wandering through the glades of the forest, and resting on the brown carpeting of fern and heather with which it is clothed, is amazed on coming suddenly in view of the rich green meadows extended for miles before it, laid in gentle slopes and artificial terraces, and preserved in perpetual verdure by supplies of water perpetually thrown over their surface. The land immediately occupied by these meadows was, in its wild state, a line of hill-sides, covered with gorse and heather—a rabbit warren, over which a few sheep wandered—and a swampy valley below, thick set with hassocks and rushes, the favourite haunt of wild ducks and snipes, through which the little stream, the Maun, wound its way in its descent from the town of Mansfield. The whole track, both upland and lowland, is of very little value. The valley was in many parts from nine to ten feet deep in bog, and almost worthless: the hill-sides varied in quality, but 80*l.* a-year would have been a full rent for the 300 acres. Indeed, the whole of the Clipstone Park farm, when taken in hand in the year 1816, containing 1,487 acres, had been let for the sum of 346*l.* In the year 1819 it occurred to the Duke of Portland that by following the stream up towards its source, and tapping it at a high level, the water might be carried over the surface of the dry and sterile hills, its course through the valley might be straitened, and the bog drained." It is needless to follow in detail the progress of the works: that they were successful is evinced by the fact of their present high rental as given by Mr Smith. That the sewage matters of the town of Mansfield have materially aided in this great result is proved by the evidence of Mr Tibbett, their intelligent manager; for Mr Denison says in another place—"The quality of the water is very important; soft water is the best—mineral waters, and waters from peat, mosses, and bogs, are found to be injurious. After strong rains, the washings of the streets and sewers of the town of Mansfield, which discharge themselves into the Maun, give great additional efficacy to the water. It will sometimes deposit a sediment in one watering of the thickness of a sheet of paper."

When Mr James Smith (of Deanston) was giving his evidence before the Committee of the Metropolitan Sewage Company, he said, when speaking of these meadows, "I have seen the Duke of Portland's meadows—the land was very poor sandy land. It cost the Duke, I believe, 30*l.* per acre to bring the land into a proper form for irrigation; but it was land, I understood, not worth 4s. 6d. per acre before;

and it now carries so many crops a year, that even in that distant neighbourhood he lets the land which is nearest the town, and receives the sewage water in its best condition, at 14*l.* an acre; the land at a greater distance he lets at 5*l.* an acre."

Leaving, however, the consideration of the meads watered by streams containing a portion of sewage matters, let us note the effects produced by waters of a purer description, and it will be well if we refresh our memories by referring to the analysis of a few spring waters. Several of these have recently been examined by Professor Johnston (*T. H. S.*, 1847, p. 50; *Johnson and Shaw's Farm Almanac*, 1840, p. 27). In an imperial gallon of various spring and brook waters he found—

LOCALITY.	SOLID MATTER.	SILICA.
Renfrewshire	7.44 grains.	0.16 grains.
"	10.64 "	0.88 "
Montrose (near)	11.36 "	1.76 "
"	22.32 "	2.56 "
Alloa (near)	12.75 "	1.56 "
Edinburgh (near)	16.20 "	0.60 "
"	23.40 "	2.20 "
Durham (county)	26.80 "	1.15 "
"	15.56 "	0.32 "
"	17.08 "	1.20 "
Inverness	5.69 "	0.40 "
Berwickshire	23.40 "	1.00 "

It was with the waters of some rills, containing a much less proportion of solid matters than any of these, that the successful attempts of Mr W. Simpson, of Glenythan, in Aberdeenshire, have been made (*Ibid.*, p. 44). He describes the rills or streams, as being supplied from several copious springs, which rise about half a mile above the commencement of one of the plots, and after running a short distance from the springs, these streams pass through a bog (now much drained, and in which other springs also rise), and all unite and form a considerable burn in one channel. Previous to the ground being operated upon for the purposes of irrigation, the burn ran through the Den in a winding course. The ground at the top of the Den consisted of a few mossy hillocks, and the other part of the ground was pretty level, of a dry nature, and covered with a short kind of grass. The ground was never cropped with grain, and the grass was not sufficient to be cut. The cattle were occasionally turned out upon it when pasture was scarce in other parts of the farm. The soil generally, except the mossy part, is alluvial in some places, and at others gravelly. The operations for irrigation began in June, 1843, and from the detail given by Mr Simpson we find that, from about five acres of this land, when formed into a water mead, were cut of grass in cartloads of six cwt.—

June, 1844	12
July	32
August	34
September	30
October	11

In 1845 was cut during—

June	13
July	36
August	43
September	42
October.	8

The tenant, it appears, now calculates the value of the meadow as being worth to him from 3*l.* to 4*l.* yearly per acre; and that if it was situated near a large town, where there is a demand by cowfeeders for grass, it would be worth double that amount. The reporter concludes, "Mr Simpson is so convinced of the great benefits to be derived from raising by irrigation large quantities of good grass, that he is in the course of turning into that every stream of water that he can command. The grass thus produced is so abundant and nourishing, that it not only rears and improves the cattle, but at the same time is the source of producing so much additional manure, as to be highly beneficial in its application to the production of grain, and also of turnips." Such were the successful labours of Mr Simpson in Aberdeenshire. The water he employed was, it seems, in no way remarkable for anything except a very small proportion which it contained of solid matters. From the recent examination of it by Dr Voelcker (*Trans. H. Soc.* 1848, p. 212) we find that an imperial gallon contains only about five grains of solid matter, this being composed of

	GRAINS.
Alkaline salts, chiefly common salt	1.14
Sulphate of lime (gypsum)	1.66
Carbonate of lime (chalk)	0.26
Carbonate of magnesia	0.46
Organic matter	0.76
Silica	0.92
	5.20

The result of this anaylsis, as Professor Johnston remarks (*Ibid.*), is very interesting. It shows that what we are in the habit of considering the purest natural spring waters, containing the smallest proportions of mineral matter, may be used with advantage for the purposes of irrigation. It is true that though the proportion of mineral matter is small, it is all of a useful kind, such as is fitted to supply the necessary wants of the growing herbage. The silica, the gypsum, the lime, the magnesia, and the alkaline salts are all food of plants, and are required in the growth of the grasses. That these ingredients do really favour vegetable growth, is shown by the numerous water-cresses which grow naturally in the water. The result is also encouraging. So long as it was believed that waters which descend from limestone districts, or which from other sources are impregnated with much mineral matter, would alone prove useful to the irrigator, doubt and hesitation could not fail to exist in the mind of the practical man as to the pecuniary advantage he might derive from any outlay upon works for irrigation. Now any

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hill-water or mountain stream, if not impregnated with iron, may be diffused over our sloping meadows with the almost certain prospect of a profitable return. We may well rejoice, indeed, at the result of these invaluable practical improvements, and at the clear and certain elucidations which chemistry brings to our aid. The march of improvement will hence, we may feel assured, be stimulated and guided on many a hill-side, in many a deep glen, where the water-plants or the mosses of the bog have hitherto only luxuriated. These must sooner or later be supplanted by useful grasses, which forming the turf of water-meads will, even in the driest and warmest seasons, only add more and more green food to the stock farms of our islands.

VI.—THE AMOUNT AND COMPOSITION OF LAND-DRAINAGE WATER.

The losses which are sustained by the soluble matters of the soil being carried off by drainage are much more considerable than is commonly supposed. And yet the largeness of the amount affords, indeed, another strong argument in favour of the necessity for returning to the soil, in some form or other, those substances which the drainage waters remove from it. This loss includes not only the substance dissolved by and carried off in land-water, but in the drainage of the farm-yard and the soakage of the compost heaps. First, then, as to the land-water, let us commence by noting the largeness of the amount of water which commonly drains or filters from the soil, before we proceed to inquire as to the substances, and their amount which it dissolves and carries away. We find from the experiments of Mr John Dickenson, of Abbot's Mill, near King's Langley, in Hertfordshire, that the amount and the way in which it was removed from the soil in eight years was as follows (*Journ. R. A. S., vol.* v, p. 151):—

YEARS.	RAIN. INCHES.	FILTRATION. PER CENT.	EVAPORATION. PER CENT.	RAIN, PER ACRE. TONS.
1836	31.00	56.9	43.1	3,139
1837	21.10	32.9	67.1	2,137
1838	23.13	37.0	63.0	2,342
1839	31.28	47.6	52.4	3,168
1840	21.44	38.2	61.8	2,171
1841	32.10	44.2	55.8	3,251
1842	26.43	44.4	55.6	2,676
1843	26.47	36.0	64.0	2,680
Mean	26.61	42.4	57.6	2,695

This amount of rain, although varying in different months, may be seen in the following table: yet, for the purposes of our present inquiry, this fact hardly affects

the result of the research. The mean amount of each month in the eight years between 1836 and 1843 was, in inches :—

		IN INCHES.		PER CENT.	
MONTHS.	RAIN.	FILTRATION.	EVAPORATION.	FILTRATION.	EVAPORATION.
January . .	1.847	1.307	0.540	70.7	29.3
February . .	1.971	1.547	0.424	78.4	21.6
March . .	1.617	1.077	0.540	66.6	33.4
April . . .	1.456	0.306	1.150	21.0	79.0
May . . .	1.856	0.108	1.748	5.8	94.2
June . . .	2.213	0.039	2.174	1.7	98.3
July . . .	2.287	0.042	2 245	1.8	98.2
August . .	2.427	0.036	2.391	1.4	98.6
September .	2.639	0.369	2.270	13.9	86.1
October . .	2.823	1.400	1.423	49.5	50.5
November .	3.837	3.258	0.579	84 9	15.1
December .	1.641	1.805	0.164	100.0	00.0
Total .	26.614	11.294	15.320	42.4	57.6

We find, then, that in Hertfordshire about 1,100 tons of rain-water annually drain away from an acre of land. That this rain-water carries away a very considerable amount of soluble substances, and that saline manures applied to the soil are thus reduced to a large extent in their amount, is not only reasonable to conclude, but has been shown by the results of various experiments. Those of Mr John Wilson, carried on in the autumn of 1844, in East Lothian, were of this kind. He observes (*Agricultural Gazette*, 1847, p. 461), that the usual quantity of rain had fallen during a winter fallow, when, on the 29th of April, he collected a specimen of water flowing from a land-drain; immediately after this sample was taken, the field was sown with barley, and top-dressed with guano. A few days afterwards, a second sample of water was taken from the same drain. On examining these it was found that 18lb. of the first specimen contained 15.2 grains of solid matter, and the same quantity of the second 27.5 grains. These, upon being analysed, were found to contain—

	APRIL 29.	MAY 16.
Organic matter and water . . .	3.4	7.8
Silica	0.9	0.7
Silicate of alumina	0.4	0.2
Chloride of magnesium	1.12	—
Common salt	1.8	2.61
Carbonate of lime	—	2.7
Chloride of calcium	3.0	2.10
Sulphate of alumina	0.85	—
Peroxide of iron	2.1	2.25
Magnesia	—	1.69
Phosphate of lime	0.3	3.1
Phosphate of magnesia	—	1.8
Phosphate of alumina	—	0.45
	13.87	25.41

The turbid portion of the drainage water first discharged from the soil, after

heavy rains, being examined by Mr Wilson, was not found to differ materially in composition from the soil which it drained; it held, however, less silica, and more lime, the matter deposited by the turbid water containing, per cent.—

Silica	60.0
Silicate of alumina	17.5
Protoxide of iron	6.5
Sulphate of lime	9.4
Sulphate of magnesia	0.75
Phosphate of lime	0.6
Alumina	4.0
Water, &c.	1.25

We have found, then, that from an acre of land in Hertfordshire, about 1,100 tons of water are annually drained, and taking the solid contents of the water to be equal in amount to the East Lothian drainage water examined by Mr Wilson, every pound weight of this removes from the land about one and a half grains of saline and finely-divided matter.

This is the case of the farm drainage in its weakest state—that from the farm-yard, it is true, is far less in bulk, but then it is very considerably more concentrated. "Both theory and experiments," remarks Professor J. F. Johnston (*Trans. H. S.* 1846, p. 187), "show this liquid to be very valuable as a manure, and it has been long known to contain substances fitted in a marked degree to promote the growth of plants; still no analyses, so far as I am aware, have hitherto been made of the liquid in the state in which it actually exists in our farm-yards, and in too many instances runs to waste. It was, therefore, with much satisfaction that I received two bottles of liquid manure for analysis from Mr Houldsworth, of Coltness, near Hamilton. The liquid contained in the first bottle consisted of the drainings from heaps of cow-dung exposed to rain. It was dark-coloured, and of course contained only what rain-water is capable of washing out of such heaps It was neutral, but ammonia was given off when it was boiled, or when quicklime was added. An imperial gallon of these drainings, when evaporated to dryness, left about 480 grains or an ounce weight of dry solid matter. This solid matter consisted of—

	GRAINS.
Ammonia	9.6
Organic matter	200.8
Inorganic matter (ash)	268.8
	479.2

The inorganic portion consisted of—

	GRAINS.
Alkaline salts	207.8
Phosphates of lime and magnesia, with a little phosphate of iron	25.1
Carbonate of lime (chalk)	18.2
Carbonate of magnesia	4.3
Silica (flint) and a little alumina (clay)	13.4
	268.8"

From this analysis the Professor draws the certain practical conclusions, that the rain is capable of washing out much valuable matter from common cow-dung. The ammonia is not so large in quantity as in many other forms of liquid manure; because most of those substances voided by the cow which are capable of producing ammonia pass off in its urine. But, on the other hand, the urine of the cow contains no phosphates, while these washings contain a considerable proportion. Those, therefore, who, besides allowing the urine from their byres to run to waste, permit the rain to wash their dung heaps, suffer a double loss: they lose the ammonia producing substances and much alkaline matter in the urine, and the phosphates with a large additional portion of alkaline matter in the washings.

The second specimen of liquid manure examined by the Professor consisted of the drainage from farm-yard dung when watered with cows' urine. It gave off ammonia copiously when boiled or mixed with quicklime. An imperial gallon when evaporated left 687½ grains of dry matter, which is considerably more than the former liquid afforded, and this matter consisted of—

	GRAINS.
Ammonia	21.5
Organic matter	77.6
Inorganic matter (or ash)	518.4
	617.5

The inorganic matter contained in this liquid consisted of—

	GRAINS.
Alkaline salts	420.4
Phosphate of lime and magnesia	44.5
Carbonate of lime	31.1
Carbonate of magnesia	3.4
Silica and a little alumina	19.0
	518.4

In this liquid, therefore, as in the other, there was a considerable proportion of phosphates, as well as a large amount of alkaline salts. There are no phosphates in the urine, but the fermentation in the dung-heap, caused partly by the watering with the urine decomposing the straw and other substances which form the dung-heap, brings a portion of the phosphates they contain into a soluble state, and thus enables them to be washed out by any watery liquid that comes in contact with them. The urine of the cow, therefore, which has been thrown upon the dung-heap will pass off, if it is allowed to escape, richer than it was at first. It may not contain so much ammonia, or those substances which produce ammonia; but it will carry away more of those inorganic substances which enter into the composition of our crops, and which are no less necessary to their growth. Other researches, instituted with the intention of ascertaining if a method could be devised of separating the fertilising substances from the drainage, have not yet been accompanied with any good practical result. Of all the substances employed, charcoal appears to be the most useful; but an adequate supply of this valuable fertilising substance, except where charred peat can be had in abundance, is only to be obtained in peculiar localities. A far more valuable direction is open to the farmer's

efforts in the prevention of such drainage, or at least its diversion to the purpose of irrigation. This last is a source of fertility that is so undoubted in its results, that I shall on all occasions which present themselves urge it on the attention of my readers. The great foundation, however, of all improvement in this way, is to be convinced of the loss which almost every farm thus incurs; for when once the enterprising and intelligent farmer is made aware of its amount and value, he will assuredly, by some improvement or other, render these matters available for the enrichment of the soil. The valuable substances drained off in the land-water seem to be more difficult to be treated; but even in those cases the researches of Mr Wilson seem to suggest the advantage of applying the requisite amount of saline manures in smaller proportions, and at intervals. And in dwelling upon the extent, composition, and uses of land-drainage water, it is cheering to find the excellent results produced upon the health of live stock and of the inhabitants of the district by its more perfect removal from the land. An instance of this is given by Mr Robert Neilson, of Hallwood, in the Appendix to a draft Report on Suburban and Land Drainage, by one of the Assistant Surveyors of the Metropolitan Commissioners of Sewers (not yet adopted by the Commissioners), p. 63. He observes—"In the Altcar meadows, belonging to the Earl of Sefton, a low level district about eight or ten miles north of Liverpool, a water-wheel was erected about five years ago for the purpose of relieving the land from inundation, and though thorough drainage has been very little adopted, the inhabitants already speak of the increased salubrity of the locality, while the equally increased fertility of the land has created a marked improvement in the condition of the stock. In my own neighbourhood, some low flat land, of a stiff clay soil, and lying extremely wet, always had a scouring effect on the young stock turned on it in spring, and no application of manure produced any alteration. It was drained, and without any other change in the management, the same species of stock throve on it extremely well."

VII.—THE DRAINAGE FROM DOMESTIC ANIMALS—URINE.

Some recent evidence, especially that by Mr Dickenson on the use of the urine of the horse on a rye-grass pasture, entirely supports the views I have before brought before my readers. I feel convinced that the use of the urine of the live stock, and the sewerage of the farm-yard, would be much more attended to than it is in general, if its value was better understood. Of its use for grass land, too, no farmer to whom I address myself will entertain any doubt. It is its careless *application*—the incorrect mode of *distributing* it on the land, that is the great cause of its neglect. There are only two ways of successfully accomplishing this,—either by ordinary irrigation, or by a water-cart. In every case where a sufficient fall can be obtained (especially if a streamlet or beck of water can be made available to increase its bulk), its use in irrigation is most certainly in every respect the best. The

grazier must discard from his mind any fear that the *dilution* of the urine destroys its power or its usefulness. It is proved by those who have tried it (a result entirely supported by my own experience), that the great danger is, by the application of such liquid matter by way of irrigation in too concentrated a state. When, however, it is necessary to apply it to grass land by means of a water-cart, then the more concentrated the fluid, the more is the expense of the cartage diminished. In this mode of application, to attain the advantages of dilution, it is only necessary to select a rainy period for the operation. I feel assured, that if my agricultural readers would but consider the great produce of grass meads thus watered, and commenced their operations in convenient localities on only a small scale, they would speedily, from their success, find means for extending these highly useful plots of grass. In this way, many years since, near Glasgow, Mr William Harley commenced. He employed the urine of the cow, in that rainy locality, in its undiluted state. This he distributed over his land by means of a fire-engine or water-cart. The result is stated by him (*Harlian Dairy System*, p. 64) to have been excellent; that in fact the grass of the fields thus irrigated was cut five or six times a year, and though not very long in the blade, was abundant in its weight: it was so thick, indeed, that it would have rotted if it had not been cut often. The first cutting generally commenced about the middle of April, and was continued once a month. The best plan was found to be to cut the grass during the day when the weather was wet or moist; but when it was dry, then it was cut late at night or early in the morning, and the field irrigated immediately after being cut. Occasionally the land was irrigated during the night. At Glasgow, at the period to which I am alluding, there was a public washing-house adjoining the dairy; all the soapsuds produced in this house were drained into a tank, and applied in the same way as the urine, and sometimes the two liquids were mixed together; or if the weather was very dry, the urine was diluted with water. Both urine and soapsuds were applied to the watering of fruit trees, to strawberries (I can assure my horticultural readers that if they will try the experiment with their strawberries, they will very soon be assured of the advantage of the plan), and in the destruction of worms. It is evident, too, from the experience of Mr W. Dickenson (*Jour. R. A. S.*, vol. viii., p. 580), that it is not necessary to have a light, or even moderately loamy soil, with a porous substratum, for this operation. He says, when recounting his valuable experience of the effects of the urine of the horse as a liquid manure on a variety of the Italian rye-grass, "My land is clay 250 feet deep; in this soil only have I had experience, so for this only do I prescribe." In referring to his experience of "a new method of cultivating a peculiar plant, whereby nine or ten crops of excellent green food had been obtained between March and December, being cut in the former month, and watered with liquid manure, consisting of one-third of horse urine and two-thirds of water, distributed from a London street water-cart, passing once over the plant immediately after the grass was cut, one watering being sufficient for one crop," he continues—"Nos. 31 and 32 are London clays without drainage, with bad crops; upon this soil, moderately under-drained, my experi-

ments were commenced, and have been carried on. I have never failed to produce every year from a portion of grass not kept for seed, from seven to ten crops." And speaking of his variety of the Italian rye-grass, he adds, "I have been convinced for some time that it luxuriates in a dry subsoil rather than in non-retentive, that it will grow rapidly in the strongest clays if not poisoned with stagnant water, and that it grows fast in any light soil well irrigated with liquid manure. I have grown it in sand from the sea-shore, moistened with liquid manure." The dressings he places in the following order:—1. Urine decomposed in a close tank, one-third urine; water, or dung water, two-thirds. 2. Guano, two or three cwt. dissolved in 3,300 gallons of water for an acre. "I do not," Mr Dickenson remarks, "place guano as an equivalent to urine; I place it as a substitute when urine has not been saved in sufficient quantity. Urine," he continues very correctly, "may be had in large quantities on every farm, by constructing, as a preliminary step, capacious tanks, and draining the stables, cattle-sheds, sewerage of the house, &c., into them. Knowing something of the value of urine," he adds, "and the profit to be derived from it, I am the more anxious to induce others to try it, and will therefore say something about the mode I have adopted to collect it, and the expense of the tanks to retain it, since this may be useful to those who have not yet set about so important an operation. Having well considered where the liquid is to be used, as well as where it is made, and resolved upon the most convenient situation, I have a hole dug full seven feet in diameter and twelve feet deep, the bottom being shaped like a basin, and well rammed with a little water into a good puddle. The construction of the tank is commenced by the bricklayer forming a circle with bricks (four-inch work), round an opening of five feet, leaving a space behind the brickwork to be fitted and rammed well in with clay puddle by the labourers as the building is worked up; no mortar being used with the bricks, or anything else, till the dome is to be formed. Mortar or cement is then required; the arch is then arched in, a man-hole being left in the centre of each tank, and covered with a three-inch yellow deal cover (two-inch oak would be better)." One of these tanks, containing 1,000 gallons, costs 2*l.* 17s. 6d., in the following items, the calculation applying to those farmers who employ their own horses and carts:—

	£	*s.*	*d.*
2 Farm labourers, each half a day	0	2	0
2 Labouring lads, each one day	0	3	0
1 Man, one day	0	2	0
2 Others, one day	0	5	0
1 Bricklayer, one day	0	4	6
1 Labourer, ditto	0	2	6
3 Horses and carts, drawing away quarter of a mile, half a day	0	4	6
8 Feet three-inch deal for cover, at 5½d.	0	3	8
Labour and nails	0	0	10
Lime and sand for man-hole	0	2	6
900 Place bricks	1	7	0
	£2	17	6

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Several of these tanks should be made adjoining each other, and I may add that I have found, in places were clay of sufficient tenacity is not procurable, that a compo or plaster, made of six parts dry sand and one part of melted pitch, used warm, forms an excellent lining for a tank. As regards the *quantity* of urine which may be collected where the proper precautions are used, Mr Dickenson states, as the result of his experience, that it amounts to three gallons per day from each moderate-sized horse, more from cart-horses that drink freely, considerably more from cows, and a much larger quantity from pigs, than is usually calculated, and in his opinion whenever a tank containing 1,000 gallons of urine is filled the second time, and properly applied to Italian rye-grass, the result, he thinks, will show it is not too high an estimate to calculate the tank and drains paid for. Professor Johnston thinks the plan so successfully followed by the Belgian farmers in the arrangement of their liquid manure tanks should be adopted. To this end the tank should be carefully covered, and divided into at least two compartments, capable of holding each two or three months' supply. When, he says (*Elements of Chemistry*, p. 160), the first of these is full, the stream is turned into the second, and by the time it is also full, the contents of the first are *ripe* or in a fit state for putting on the land. The liquid ought always to be in a state of fermentation before it is applied either to grass or to any other crop. This double tank also enables the farmer to collect and preserve his liquid during the three months of winter, when it cannot be applied, and to have a large supply in a fit state for putting on when the young grass or corn begins to shoot. The liquid as it comes from the cattle he thinks should be mixed with at least its own bulk of water; by this means a considerable loss of ammonia is prevented, which would otherwise escape from the urine during fermentation, and it is prevented from burning the grass, which in very dry seasons it is apt to do when put on without dilution. The amount of the urine of a cow he calculates to be equal to from 1,200 to 1,500 gallons a year; he adds, "we may safely estimate the solid matter given off by a healthy animal in this form to be equal to 1,000 lb. weight, worth, if it were in the dry state, from 4*l.* to 5*l.* sterling. In the liquid state, the urine of one cow, collected and preserved as it is in Flanders, is valued in that country at about 2*l.* a year. In another place (*Transactions of the Highland Society*, 1846, p. 309), the same laborious chemical philosopher has given us the analysis of the urine of the sheep, from which one chief fertilising effect of sheep-folding is derived to the farmer's land. It is, as the Professor remarks, in commenting upon the results of the analysis, to be classed with the urine of the ox and the horse. He found in 1,000 parts of the urine of the sheep—

Water	928.97
Urea	12.62
Organic matter	36.95
Sulphate of potash	0.51
Sulphate of soda	1.32

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Chloride of potassium	2.05
Common salt	5.47
Chloride of ammonia	3.00
Carbonate of soda	7.22
Carbonate of lime	0.14
Carbonate of magnesia	0.08
Phosphates of lime and magnesia	0.12
Silica	0.18

Even the urine of the sheep is rendered available in the formation of artificial mixtures of urine with water, for liquid manure, by the shed or the yard system of feeding. A considerable amount of labour in the application of liquid manure may in many instances be saved by the use of a forcing pump, in the manner adopted by the Rev. A. Huxtable. It was thus described by him in his speech at Sir Robert Peel's in Staffordshire, September 1847, (*see Publication of Metro. Sewage Manure Company*, edited by Dr Guy, p. 46.)

" First the liquid manure flows into large tanks; *below* them is another, in which the manure is diluted with water as the weather may require, the rule being, that the hotter the weather the weaker the manure. I have laid down over the highest part of my farm a main of green elm pipe, of two inches diameter, bored in the solid wood; at every hundred yards' distance is an upright post, bored in the same manner, with a nozzle. A forcing pump, fixed at the mixing tank, discharges, along these pipes, buried two feet in the ground, the fluid with a pressure of forty feet. Of course it rushes up these pierced columns, and will discharge itself with great velocity through the nozzle. To this I attach, first of all, forty yards of hose, and thenceforth water all the grass which it can reach. To the end of this hose another forty yards of hose are attached, and a still larger portion of the surface is irrigated; and so on for as many yards as are required. When enough has been irrigated at the first upright, the nozzle is plugged, and the fluid is discharged at the second column, and so on. The cost of the prepared canvass hose, which was obtained from Mr Holland, of Manchester, was 1s. a yard: the wooden pipes cost me only 1s., and being underground they will be most enduring.

" By the outlay of 30*l.* I can thus irrigate forty acres of land; and see how inexpensive, compared with the use of the water-cart and horse, the application ! A lad of fifteen works the forcing pump; the attaching the hose and its management require a man and a boy. With these, then, equivalent to two men, I can easily water two acres a day, at the rate of forty hogsheads per acre, of the best manure in the world. I say *best*, because all chemists will assure you that the liquid contains the principal nitrogenous and soluble salts, and therefore is far more valuable than the dung, and it is plain enough to every man, though he be no chemist, that plants can only take up the manure in a liquid form. The principal use which I make of the hose is to water the clover, and above all the Italian rye-grass. From my own observation I know that if after each cutting the hose immediately follows, you may cut it without wrong to the land as often as

you like, and an amount of fodder will be obtained which no other plant can approach. It comes the earliest and grows the longest of all the grasses, and I feel confident that, with such appliances as I have mentioned, you may secure fifty tons per annum of this milk-giving, fat-producing, muscle-making grass. I can refer to Mr Dickenson, of Curzon street, as an authority for growing at least this weight of green food, and I believe far more. That you may cut it by the help of liquid manure six times a year, admits of no doubt." [The liquid manure here referred to is that of cattle kept on boards.]

But I need not multiply instances of the various modes by which liquid manure may be profitably prepared by the practical English farmer. It is a source of riches which, varying his mode of operation with the circumstances in which he is placed, is much too valuable to be long neglected. In such improvements as these, too, let him remember, he is not adventuring his time and his capital on untried fertilisers; he is merely saving and applying the proportion of those powerfully-enriching fluids which have been hitherto allowed to be profitlessly absorbed by the bottom of the farm yard, or perhaps the ditch by which it is surrounded.

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Printed by Reynell and Weight, 16 Little Pulteney street.